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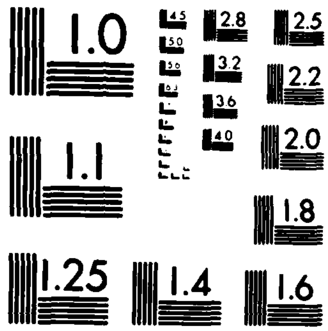

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THE EEC'S INFORMATION TECHNOLOGY PROGRAM--AN UPDATE
J.F. BLACKBURN
18 DECEMBER 1984

UNITED STATES OF AMERICA

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The primary goal of the European Strategic Program for Research and Development in Information Technology (ESPRIT) is to make the countries of the European Economic Community competitive in the world market for information technology.

This report examines the five areas of the ESPRIT program for 1985: advanced microelectronics, software technology, advanced information processing, office systems, and computer-integrated manufacturing.

THE EEC'S INFORMATION TECHNOLOGY PROGRAM--AN UPDATE

1 INTRODUCTION

The primary goal of the European Strategic Program for Research and Development in Information Technology (ESPRIT) is to make the countries of the European Economic Community competitive in the world market for information technology. This report updates an article published in *European Scientific Notes* in May 1984 (*ESN* 38-5: 248-252). ESPRIT's pilot phase of 36 projects (selected from over 200 submissions) at a cost of 23 million European Currency Units (ECUs; 1 ECU equals about $0.72) was listed *ESN* 38-5. In addition, the EEC announced at the end of July 1984 the launching of 90 new transnational R&D projects to start the main phase of the 10-year ESPRIT program. The EEC committed 200 million ECUs in 1984 to a total of well over 100 projects, including some of the pilot programs which will become part of the main program.

The 90 projects for the main phase of ESPRIT were selected from 441 proposals. These represented a total funding requirement of 1.9 billion ECUs, as compared with the total of 1.5 billion ECUs agreed for the first 5 years (1984-88) of the ESPRIT main phase. The average number of partners in the approved projects is four, although some have as many as 10. According to the rules, 50 percent of the funding must come from industry and the remaining 50 percent from the EEC. There must be two separate industrial partners from different EEC countries in each project.

This report will describe the ESPRIT plan for 1985, which includes five subprograms:

- Advanced Microelectronics
- Software Technology
- Advanced Information Processing
- Office Systems
- Computer-Integrated Manufacturing

Details on the 90 approved projects had not been made public as of December 1984. However, considerable detail on the five subprograms is given below.

2 ADVANCED MICROELECTRONICS

The purpose of this subprogram is to develop the key technologies of silicon metal oxide semiconductors (MOS) and of bipolar and gallium arsenide (GaAs) semiconductors with the associated computer-aided design (CAD) capability. When associated with CAD and manufacturing methods, these technologies are expected to produce by 1988 a soundly based industrial capacity to produce 1-micron circuits in a number of European sites, with substantial progress toward submicron capability. Also the necessary CAD capability to design very large scale integrated (VLSI) circuits should be in place by then. Communication with other subprograms will be required to ensure the required VLSI demonstrator circuits are designed and fabricated. It will be necessary to increase the number of trained science and engineering personnel in microelectronic design and process technology. A reasonable level of support is provided for longer range work, such as optoelectronics.

A total of 13 CAD projects involving about 650 man-years between 1983 and 1987, supported by EEC Microelectronics Regulation 3744/81 and the ESPRIT pilot phase, are under way and a new project is now being launched.

Computer control of manufacturing VLSI circuits is seen as an essential part of the program. The reduction in feature size and layer thickness place increasing demands on process control where the number of variables is large. The submicron MOS and bipolar projects will include computer-aided manufacturing aspects as appropriate.

Submicron MOS

During the first year the submicron MOS project will choose the process and design methodology and establish the process steps. During the second year the individual process steps will be optimized, and preliminary design rules will be established. Research will then be

started on process and structures for submicron technology. In the third year the objective is to demonstrate feasibility with a 1-micron feature size, 0.5 million components circuits, followed by evaluation of the steps and the equipment. In the fourth year the submicron lithography equipment will be chosen, and a flow chart and design rules for a 0.7-micron process will be compiled. During the fifth year an evaluation of a 0.5-micron process will be made and its process feasibility demonstrated. A circuit with more than 1 million components will be designed and demonstrated.

Submicron Bipolar

The submicron bipolar process will follow a similar pattern to that of the MOS process over the 5-year period.

Computer-Aided Design

The need in a CAD integration project is for a wide and representative group of design automation tool developers to recommend the mechanisms and framework for better integration and wider accessibility of European CAD tools. The work will take into account worldwide development in information technology and design automation systems architecture. In the first phase (first and second years) problems of bridging existing tools and assessing the impact of networks and distributed data will be undertaken. Data and portability standards will be recommended, and guidelines for developing design automation tools will be given. Tools and systems currently under development will be integrated into a first generation system. During phase two (years three, four and five) extensions will be made to incorporate the impact of new developments in design automation, artificial intelligence, and database technology. Integration of a second-generation system, including advanced tools will be accomplished. Finally, existing standards will be reviewed and updated.

A user interface project will be started to promote more effective use and consistency in CAD tools. In the first year, the user interface aspects of present CAD systems will be improved toward user friendliness, quick response time, portability, and consistency. During the second year, links on communications between intelligent work stations and the central computing units will be investigated for speed of transmission, protocol of transmission, and the partitioning of data and processes between work stations and computers. Finally, in years three and four man-machine interface will be studied with respect to CAD and new input/output techniques--e.g., voice input.

The special problems of VLSI will require development of new algorithms and architectures for circuits containing millions of transistors. During the first year, performance evaluation criteria will be established with respect to layout generation, floor planning, and functional design tools. The second year will be devoted to experimenting with existing tools, artificial-intelligence systems, and special hardware. A demonstrator system will be defined in which to make cooperative algorithmic tasks with artificial-intelligence techniques and special-purpose hardware. Years three and four will be devoted to implementation of the system and demonstration on difficult and large problems. High-level design tools will be developed for specification synthesis and verification with a high degree of technology independence. The largest designs which may contain both memory and logic are 10 million components per chip. A number of small and highly innovative projects will be supported, including 50-picosecond VLSI circuits, wafer yield, parallel architectures, gallium arsenide technology, and special-purpose hardware for CAD. Cells which can be used to evaluate silicon technologies and CAD tools developed under ESPRIT as working circuits must be provided. Primitive, parameterized, and fixed cells will be included.

Compound Semiconductor Integrated Circuits

Integrated circuits in III-V compound semiconductor materials offer speed or speed-power-product advantages over

silicon because of higher electron mobility. The technology includes GaAs circuits based on field effect transistors as well as GaAs/GaLAs heterojunction structures using high electron mobility transistors. Basic research is needed in materials preparation, ion implantation, and integrated circuit process technologies. By the end of the fifth year the intent is to demonstrate a large circuit of 10k to 20k gates complexity with gate delay of less than 50 picoseconds with figure of merit less than 100 femtojoules.

Optoelectronics

Optoelectronics devices will be increasingly needed for telecommunications transmission, intra- and extra-computer connections, ultra-wide-band image processing and switching. Future generations of mono-mode communications systems may use coherent detection and multi-channel wavelength multiplexing and may be phase modulated. This will provide improved performance and will be compatible with integrated optical logic and will allow processing, combining, and routing at very high speeds. In semiconductor form it will also be compatible with III-V integrated circuits providing a fast electrical interface. The two approaches are: (1) integrated electronic and optical components on the same chips, and (2) wavelength multiplexing with integrated optics.

The objective with the first approach is to demonstrate an integrated transmitter with a bandwidth greater than 2.5 GHz by the end of the third year. The objective of the second approach is to demonstrate an integrated wavelength multiplexing transmitter module and receiver module.

Advanced Display Technologies

In many areas there is a need for new, advanced, display systems to supersede the conventional CRT. These displays need to be large, with medium to high definition. Color may also be desirable. A technology definintion project in which existing community practitioners would combine their knowledge and experience is proposed. The expected results of a 12- to 18-month project would be a study report supported by one or more demonstrators.

General Research Themes

Two examples of this research area are:

1. An investigation of all aspects of the interconnection of high-pin-count integrated circuits.

2. Investigation of plasma-deposition technology for magnetically recoding on thin film media.

Projects in Support of More Than One Microelectronic Area

Several examples of such projects are:

1. Advanced interconnections for VLSI circuits. This project relates to the on-silicon interconnection problem. It will deal with multilayer and submicron geometries and will address the relevant materials technology and other related problems. Reliability, life-test, and yield programs will form an integral part of the project.

2. Automatic design validation of integrated circuits using electron beams. This project will develop a methodology for the automatic-design-errors diagnosis of VLSI devices based on the observability facility given by an electron-beam system; connection to the CAD environment; pattern recognition to automatically position the electron beam; global methodology, possibly based on expert systems to define the diagnostic strategy; and new hardware circuitry to enhance performance. The areas of computer control of the electron beam system, interfacing to CAD software, identification of circuit elements, methodology for design error diagnosis, test pattern generation for electron-beam debugging, design for electron beam testability, and development of electron-beam equipment will be addressed in order to achieve this overall objective.

3. Assessment of silicon molecular-beam-epitaxy (MBE) layers. The three parts of this project are:

- Growth of silicon layers by MBE.
- Continuing *in-situ* measurement of process characteristics.
- Implementing and developing techniques for the characterization of MBE layers. This information will be used to optimize growth conditions.

4. Silicon-on-insulator system combined with low temperature. A number of techniques will be used and combined to obtain good quality, single-crystal layers with thicknesses varying between 0.5 micron and 50 microns for a variety of applications.

5. A high performance complementary metal-oxide-semiconductor (CMOS) bipolar process for VLSI circuits. This project is to develop a VLSI technology which combines on a single chip MOS circuitry of the highest density presently obtainable, with bipolar circuitry of similar density, but better suited to specific tasks like interfacing with external equipment.

6. Improvement of yield and performance of integrated circuits by design centering. The new method of design centering will be applied to optimize the performance of the integrated circuits. Additions to an existing program will include schematic input, output of relevant results and an improvement of the search strategy in order to reduce CPU time.

7. Substrates for CMOS VLSI technology. One objective is to set up an intrinsic gettering process for wafers with medium-high oxygen concentration. A second objective is to characterize epiwafers with diameter of 4 and 6 inches. The thickness of the epilayer should be in the range 5 to 10 microns.

8. Quantum semiconductor devices. The plan is to explore device structures where the carriers are controlled within and between layers by electric fields imposed by implanted/diffused regions, or by specially configured gate structures.

9. Dopant profiling for submicron structures. The plan is to realize the capabilities of the accurate determination of shallow dopant profiles as used in submicron devices.

10. High-resolution plasma etching in semiconductor technology fundamentals, processing, and equipment. The program will bring together centers of expertise in plasma chemistry and physics, instrument manufacturers and a supplier of chemicals to the electronics industry.

3 SOFTWARE TECHNOLOGY

The three main R&D areas in this subprogram are: theories, methods, and tools; management and industrial aspects, and common environment.

Theories, Methods, and Tools

In the short term the project will work toward unification and integration of the existing models and tools in software production. The purpose is to lower the threshold which prevents software engineers from using these tools. In the longer term, stress will be put on the view of the system as a whole to unite the classically separated processes of software production and hardware development. Three main themes have been selected in the area of system-oriented approaches: hardware/software synergy; requirements engineering; and design of secure systems.

In hardware/software synergy the objectives are:

- To develop common techniques, methods, and tools for the whole system-development process.
- To develop an integrated approach to modeling the overall system. This should achieve cost-effectiveness and adequacy of the system as a whole.
- To enable automated transformation of formal specifications into silicon/software.
- To develop test and evaluation strategies regarding the increased complexity of such systems.

The objective in requirements engineering is: to develop a formal framework, methods, and tools for the capture and description of system requirements. This is a problem of fundamental importance to all information-technology product development.

In the design of secure systems the objective is to develop methods and techniques for designing and implementing systems that must be safeguarded from stated infringements--e.g., because they deal with sensitive data, or because resource usage must be strictly controlled for accounting purposes. The methods and techniques must provide the integrity properties. The techniques must be able to deal with a distributed network of users with multiple levels of allowed access.

Advanced software development approaches will investigate: (1) the possibility of integrating the software engineering approach and the experimental style of software development exemplified by knowledge-processing work, and (2) the provision of facilities for rapid incorporation of future developments in different classes of languages. Some examples of this advanced work are:

1. An integrated formal approach to industrial software development. This project will integrate the object-based language paradigm, the algebraic approach to software specification, the relational approach and so-called formal heuristic.

2. Investigation of performance achievable with highly concurrent interpretations of functional programs. This project will investigate the performance implications of the highly concurrent hardware architectures which are becoming available on the use of the functional programming approach to application development.

3. An advanced support environment for method-driven development and evolution of packaged software. This project will develop techniques for the formal definition of methods used in the development of software. The main idea is building a support environment parameterized by methods expressed in a development language.

4. Expert system-based software systems construction. The purpose is to investigate in detail the possible contribution of an extended expert system on the base of the collected, existing knowledge on system development, knowledge acquisition on system development, and prototype-generation by direct derivation from specification.

5. Development of system software using nonimperative languages. The objective is to design concrete formalisms and languages based on nonprocedural and nonimperative approaches, such as those found in functional, applicative, logical, and algebraic programming styles. A further objective is to build support systems for rapid prototyping, integrating the various abstract concepts for describing distributed systems, including temporal logic, data-flow languages, and calculi of communicating systems.

Management and Industrial Aspects

The subareas under this topic are: software production and maintenance support, which deal with the support system aspects; industrialization aspects, which address the introduction strategy; development of project management tools; and management of advanced software production.

The objectives of the software production and maintenance support are:

- To produce a system providing integrated management capabilities with software engineering tools based on available or near-term technology.
- To evaluate through practical use the effectiveness of such a management support system as representing the current or near-term state of the art.

The objectives of the industrialization aspects are:

- To develop models of the full software-development process, taking into account all peripheral activities, such as management, personnel, training, and investment strategies.
- To develop and assess alternative strategies for the introduction of software technology into the commercial environment. The alternatives should include central software factory, decentralized specialist units, and work station-based strategies

including incremental growth from a small number of units.

- To produce case studies which support the model in a variety of industries.
- To develop techniques and, where appropriate, tools to help industry adopt software technology.

The project management tools program has the objective of developing specific tools for project management, in the form of linked sets of tools for specific application areas.

The project on management of advanced software production has the following objectives:

- To establish the impact on the relationship between the technical aspects of software development and management features.
- To evaluate risks and help decision makers through the software-product life cycle.
- To demonstrate and evaluate advantages to the software-product life cycle of advanced techniques.
- To identify and satisfy management requirements which result from the use of advanced techniques.
- To achieve performance management and capacity management in the new setting.

Common Environment

An area of importance to European industry concerns the development of embedded systems. This requires the use of special environments which can deal with host/target interworking. However, a common environment can be used as a primitive software development environment and as a basis for the development of a complete, integrated, software-engineering environment.

Since multinational development of software is a central feature of the ESPRIT program, the common environment is an important building block for many projects promoting standardization of tool interfaces, functions, and portability. There will be an early publication of all interface definitions so that widespread exploitation of the environment is facilitated.

A project called "A Basis for a Portable Common Tool Environment" will provide a common base for software engineering. The project will exploit and advance state-of-the-art technology in the areas of user environment interface and management of information bases.

A "Common Environment Tools and General Services" project concerns the construction of an integrated tool set based on portable, common tool environment, of interest to most professional software developers.

In embedded systems the host computer used for system development and the target computer on which the system is to run are not the same. It should be possible to connect the host and target computers for development and for maintenance. This causes problems which may be attacked by introducing the concept of target environment, which acts as a framework for operating systems and application components and as an interface to the host. A number of projects will cover the themes arising from this problem.

Evaluation and Demonstration Projects

The ESPRIT program should include segments which contribute to the production of reliable information about the usability of software technology results in the widest sense in typical industrial situations. The idea is to use real projects as an evaluation and demonstration vehicle. It is important that the results produced be relevant to a significant sector of industry, in terms of the application area and of the working mode.

Proposals to be considered in this area may relate to theories, methods, and tools or to management and industrial aspects.

4 ADVANCED INFORMATION PROCESSING

The areas to be considered under this subprogram are: knowledge engineering, external interfaces, information and knowledge storage, computer architecture, design and system, and focusing projects.

Knowledge Engineering

This area is concerned with the tools and technologies which will be needed for the practice of knowledge engineering in order to realize commercially and socially acceptable knowledge-based systems applications, of which expert systems, decision support, and computer-aided instruction are examples. The specific topics to be covered under this heading are:

- Knowledge representation and inference techniques.
- Knowledge acquisition and learning techniques.
- Knowledge manipulation.
- Dialogue and natural language.
- Implementation languages.
- Interpreters for high-level knowledge representation formalisms.
- Knowledge-based systems and their metrication.
- Advanced generation knowledge-based systems applications.

External Interfaces

This research area is concerned with how the computing system communicates with its environment, especially with reference to speech and visual signals. The work will deal with recognition, interpretation, and synthesis of signals. Two types of external interface occur: those that extract their information by direct natural communication, and those that acquire knowledge by means of their sensors. The three main headings of research that fall under this area are:

- Image processing, including two-dimensional picture processing, depth and motion analysis, and picture synthesis.
- Speech recognition.
- Multi-sensor signal processing and optical signal processing.

Information and Knowledge Storage

The effectiveness of a knowledge-based system is determined by the quality of its knowledge base and of the architecture, function, and performance of its knowledge store and its deduction mechanism. Those concepts will also be useful in improving the accessibility of more conventional databases to the human user, so coordination is needed with the evolutionary improvements in database management systems proposed in software technology projects.

The research topics to be covered in this area are:

- Interface between storage and environment.
- Data and knowledge bases, including: knowledge bases for advanced information processing, distributed databases and knowledge bases, and advanced database management systems and knowledge-based management systems.
- Storage structures and architectures, including: database- and knowledge-base-oriented architectures, performance models for storage structures, and storage architecture.
- Medium-term research on applications of new magnetic and semiconductor storage media.
- Long-term research on optical and biological storage.

Computer Architecture

New forms of computer architecture will be investigated in this research area. VLSI technology provides the means of creating new architectures using a large number of parallel processors running concurrent tasks. The main topics to be investigated in this area are:

- Ultra-computer, multiprocessor machines.
- Non-von Neumann architectures, including highly parallel computer architecture, data-flow machines, reduction machines, and inference machines.
- Programming environments for non-von Neumann architectures.

Design and Systems Aspects

Research in this area will cover standards, special specification and verification techniques, design methods, general system methods, and catalogues of information and technical monitoring

which are relevant to the other activities of the advanced information processing subprogram.

Topics to be included in this area are:

1. A life-cycle model of advanced information-processing systems which will cover requirements definition and validation, design, implementation, testing, maintenance, configuration and project management. The objective is to identify an adequate range of effective methods and techniques of producing and maintaining advanced information processing systems. The systems must be reliable, secure, and tolerant, and must provide tool support for these methods and techniques, assuming several levels of representation with incremental verification and validation.

2. Advanced interactive environment for advanced information processing. This task will develop advanced environments to support the formal interactive style of program development.

Focusing Projects

The ESPRIT program eventually should include a number of integrated, interdisciplinary projects that span the aspects of advanced information processing and other areas of the ESPRIT program. A possible project could be defined in the area of health care, where the knowledge-engineering results from research in that area could be combined with results from research in multi-sensor signal processing and speech recognition, knowledge storage, architectures and project life-cycle.

During 1985-86, proposals will be invited to carry out surveys which will elucidate the foreseeable effects of the implementation of information technologies in areas with clear public impact or with important implications for the quality of working life. During 1986-88 proposals may be invited to combine the results of work in microelectronics, software technology, advanced information processing, and possibly office systems and computer integrated manufacturing.

5 OFFICE SYSTEMS

Research in office systems can be characterized on the basis of fundamental and methodological developments in VLSI circuits, software technology, and advanced information processing and other fields. Integrated and applied system solutions are developed which take into consideration user requirements and foreseeable modification in the technical, social, and economical field.

Five research areas are described below.

1. Office system science and human factors, in which the aims are:

a. To analyze current and predicted office activities to determine how information technology might be applied to improve the effectiveness of office work and organization and of the enterprise as a whole.

b. To improve understanding of human factors in the office and to ensure high performance of users when interacting with the systems and at the same time offering optimal working conditions and ensuring adequate organization and individual acceptance.

2. Advanced work station and human-machine interfaces. The purpose is to establish major new human-machine interface technologies, peripheral technologies, and document-representation technologies and information manipulation relevant to the development of advanced office work stations for use in advanced office systems.

3. Communication systems. The objective is to create the basic technologies required for advanced office communication systems, including technical fundamentals in communication systems architecture, optical technologies as a particularly significant technology, the management of resources connected by networks, and system aspects of value-added services.

4. Advanced multimedia storage and retrieval systems. The purpose is to acquire the system and applications expertise related to adequate storage and retrieval of all forms of office

information in electronic storage systems in a user organization.

5. Integrated office information systems. The objective is to enable checking the validity of the total information concepts that are advocated in environments that are realistic and that allow quantitative evaluation.

6 COMPUTER-INTEGRATED MANUFACTURE

This area covers the total range of manufacturing activities, including CAD, computer-aided engineering, computer-aided manufacturing, flexible machinery and assembly systems, robotics, testing, and quality control.

The objectives are to create an environment in which multivendor systems can be implemented in a progressive manner, and in which community information-technology suppliers can compete effectively. Work is needed on infrastructures, which concentrates on the development of design rules and architectures leading to a common reference frame. Relevant international standards activity must be continuously assessed, and areas identified in which European action could be supported. Also, action is required on those subsystems, interfaces, and tools whose development or refinement is judged to be of strategic value for EEC industry.

CONCLUSION

The response of companies and universities throughout the EEC to the request for proposals in the ESPRIT must have been gratifying to the community. Having 441 proposals from which to select 90 projects indicates a good probability of choosing good projects.

The 1985 work program described in this report is indeed comprehensive. Some idea of the competence of the companies and universities selected for the 90 approved projects can only be estimated when the names and proposed approaches are made public sometime in early 1985. However, even if we assume highly competent work on individual projects, the coordination and overall management of the entire ESPRIT program will be extremely difficult. It will be much more difficult than the management and coordination of programs operating in a single country like the Alvey Program in the UK and the Fifth Generation Program in Japan. Even those programs are much more difficult to manage than programs within a single company. A single company like IBM has sometimes found difficulty in coordinating the work carried out in subsidiaries in a number of countries. Although IBM has largely solved that problem through an excellent intracompany communications system, the communications problem for ESPRIT will be vastly more difficult.

A shortage of skilled manpower in all of the 10 EEC countries in the highly specialized subject matter required by the ESPRIT program will be a factor militating against complete success. It will be difficult enough for countries like the UK, France, Germany, and Italy to find the skilled manpower to adequately staff their own national programs.

The required involvement of both companies and universities in the projects is a positive factor. If this can be managed smoothly in individual parts of the program, then these individual parts are likely to be successful in a reasonably large number of cases.

On balance, the ESPRIT program is about as ambitious as the Japanese Fifth Generation program in its objectives--and ESPRIT has far more management and coordination problems to overcome. Despite all the problems, there is enough outstanding talent in the member countries to ensure at least a modest measure of success. Success in the ESPRIT program, at even a moderate level--combined with some success of the national programs in the UK, France, and Germany--will make Europe a strong force in the information systems market in the 1990s. Europe, because of its division into many countries with special national objectives, is unlikely to overtake either the US or Japan as a supplier of information systems or information technology. However, Europe may become a very strong third supplier of such equipment during the next decade. A more definite assessment can be made in about another year.